Animation and Interactivity

Grayson White

Math 241

Week 3 | Spring 2026

Announcements

- Office Hours Schedule
  - This week, my Friday office hours have been moved to Thursday.
- Problem Set 1 due **tomorrow** at 9am.

Week 3 Goals

Mon Lecture

- Think about reproducibility and learn how to ask coding questions well.
- Motivate and work on data wrangling.

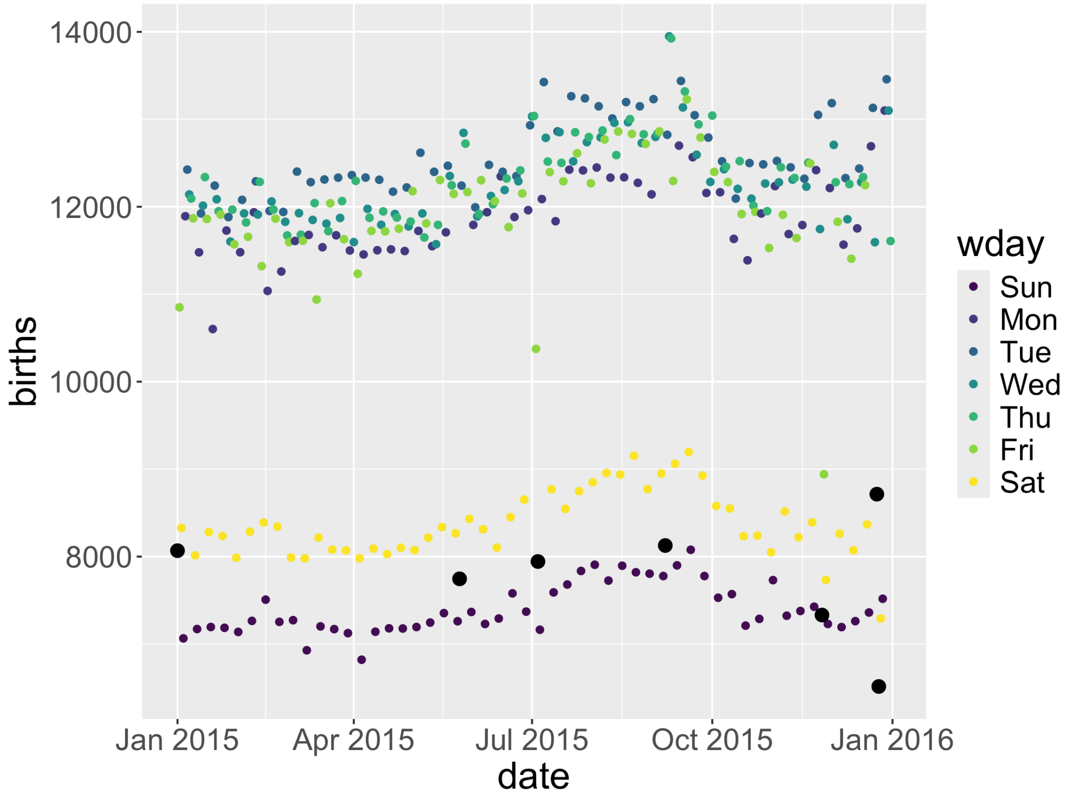
Wed Lecture

- Recall some ideas about inheriting aesthetics.
- Plot animation and interactivity.
- Formalize some ideas about GitHub workflow and RStudio Projects / Positron folders.

First up: some further discussion of inheriting aesthetics

Inheriting `aes` from `ggplot()`

```r
ggplot(data = Births2015,
       mapping = aes(x = date, y = births,
                     color = wday)) +
  geom_point() +
  geom_point(data = holidays, size = 3,
             color = "black")
```



- What `aes`thetics did the second `geom_point()` inherit? What didn't it inherit?

```r
glimpse(Births2015)
```

```
Rows: 365
Columns: 8
$ date         <date> 2015-01-01, 2015-01-02, 2015-01-03, 2015-01-04, 2015-01-…
$ births       <dbl> 8068, 10850, 8328, 7065, 11892, 12425, 12141, 12094, 1186…
$ wday         <ord> Thu, Fri, Sat, Sun, Mon, Tue, Wed, Thu, Fri, Sat, Sun, Mo…
$ year         <dbl> 2015, 2015, 2015, 2015, 2015, 2015, 2015, 2015, 2015, 201…
$ month        <dbl> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, …
$ day_of_year  <int> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17…
$ day_of_month <dbl> 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17…
$ day_of_week  <dbl> 5, 6, 7, 1, 2, 3, 4, 5, 6, 7, 1, 2, 3, 4, 5, 6, 7, 1, 2, …
```

```r
glimpse(holidays)
```

```
Rows: 7
Columns: 9
$ date         <date> 2015-01-01, 2015-05-25, 2015-07-04, 2015-12-25, 2015-11-…
$ occasion     <chr> "New Year", "Memorial Day", "Independence Day", "Christma…
$ births       <dbl> 8068, 7746, 7944, 6515, 7332, 8714, 8127
$ wday         <ord> Thu, Mon, Sat, Fri, Thu, Thu, Mon
$ year         <dbl> 2015, 2015, 2015, 2015, 2015, 2015, 2015
$ month        <dbl> 1, 5, 7, 12, 11, 12, 9
$ day_of_year  <int> 1, 145, 185, 359, 330, 358, 250
$ day_of_month <dbl> 1, 25, 4, 25, 26, 24, 7
$ day_of_week  <dbl> 5, 2, 7, 6, 5, 5, 2
```

Inheriting aes from `ggplot()`

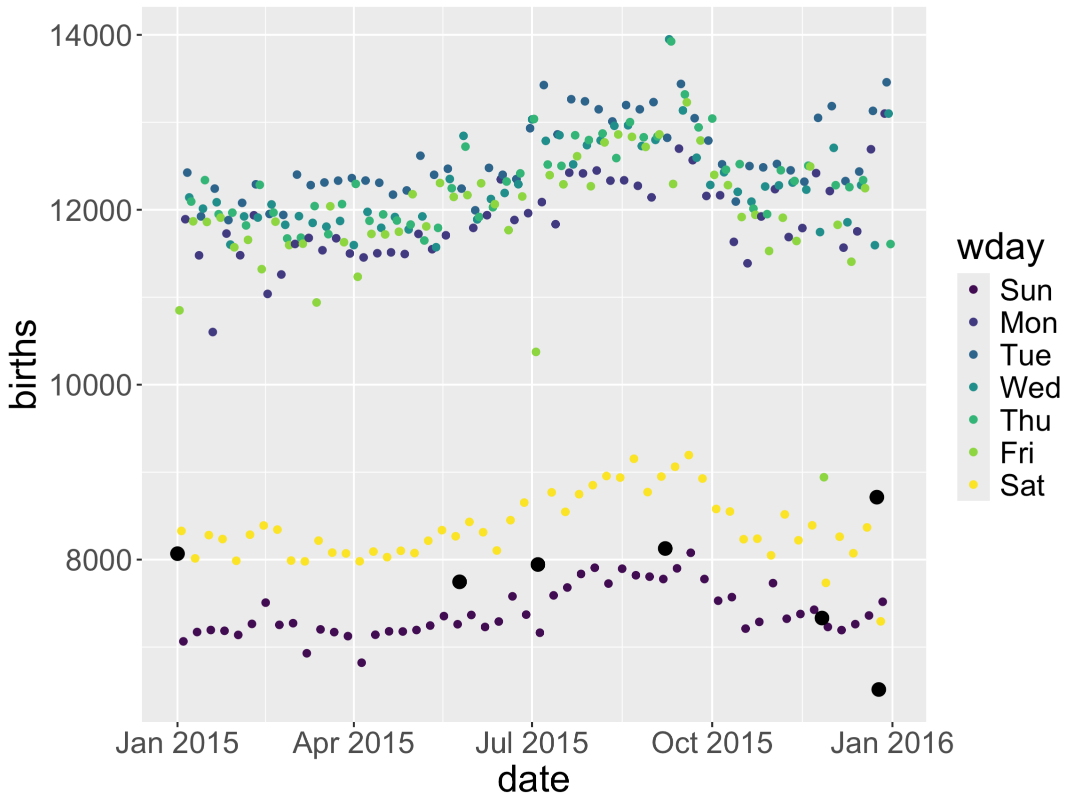
- What aesthetics did the second `geom_point()` inherit? What didn't it inherit?

```r
holidays <- rename(holidays, Dates = date)

ggplot(data = Births2015,
       mapping = aes(x = date, y = births,
                     color = wday)) +
  geom_point() +
  geom_point(data = holidays, size = 3,
             color = "black")
```

```
Error in `geom_point()`:
! Problem while computing aesthetics.
ℹ Error occurred in the 2nd layer.
Caused by error:
! Aesthetics are not valid data columns.
✖ The following aesthetics are invalid:
• `x = date`
ℹ Did you mistype the name of a data column or forget to add `after_stat()`?
```

Inheriting `aes` from `ggplot()`

```r
ggplot(data = Births2015,
       mapping = aes(x = date, y = births,
                     color = wday)) +
  geom_point() +
  geom_point(data = holidays, size = 3,
             color = "black",
             mapping = aes(x = Dates))
```



- What `aes`thetics did the second `geom_point()` inherit? What didn't it inherit?

Inheriting aes from ggplot()

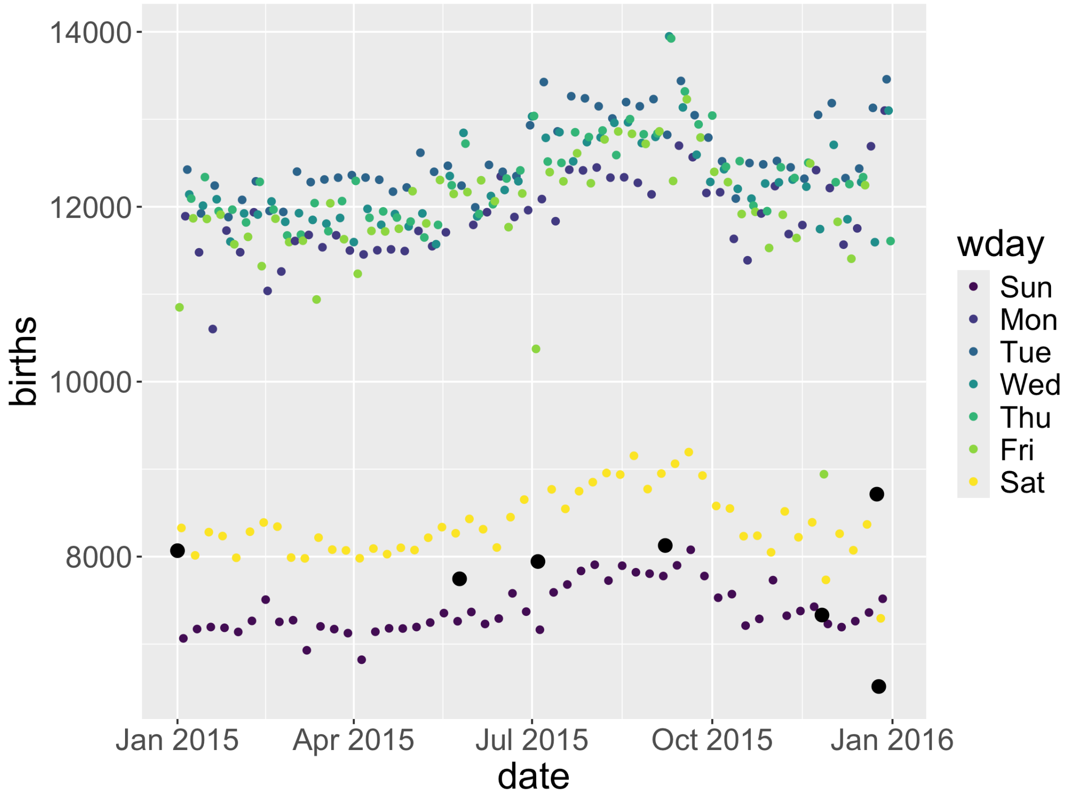
```r
ggplot(data = Births2015,
       mapping = aes(x = date, y = births,
                     color = wday)) +
  geom_point() +
  geom_point(data = holidays, size = 3,
             color = "black",
             mapping = aes(x = Dates),
             inherit.aes = FALSE)
```

```
Error in `geom_point()`:
! Problem while setting up geom.
ℹ Error occurred in the 2nd layer.
Caused by error in `compute_geom_1()`:
! `geom_point()` requires the following missing aesthetics: y.
```

- What aesthetics did the second `geom_point()` inherit? What didn't it inherit?

Inheriting `aes` from `ggplot()`

```r
ggplot(data = Births2015,
       mapping = aes(x = date, y = births,
                     color = wday)) +
  geom_point() +
  geom_point(data = holidays, size = 3,
             color = "black",
             mapping = aes(x = Dates,
                           y = births),
             inherit.aes = FALSE)
```



- What `aes`thetics did the second `geom_point()` inherit? What didn't it inherit?

Inheriting aes from ggplot()

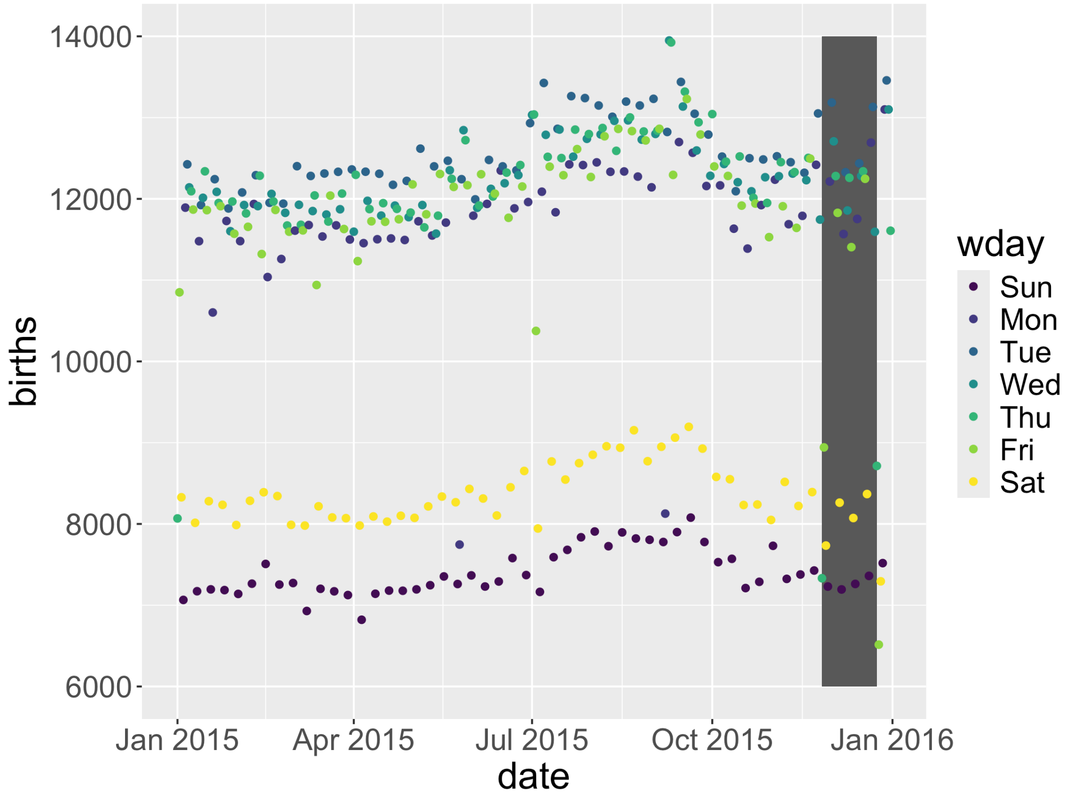
```r
#Add a box around Thanksgiving to Christmas
holidays_season <-
  data.frame(start = as_date("2015-11-26"),
             end = as_date("2015-12-24"))

ggplot(data = Births2015,
       mapping = aes(x = date, y = births,
                     color = wday)) +
  geom_rect(data = holidays_season,
            mapping = aes(xmin = start,
                          xmax = end,
                          ymin = 6000,
                          ymax = 14000)) +
  geom_point()
```

```
Error in `geom_rect()`:
! Problem while computing aesthetics.
ℹ Error occurred in the 1st layer.
Caused by error:
! object 'births' not found
```

- Problem: non-matching aes arguments

Inheriting aes from ggplot()

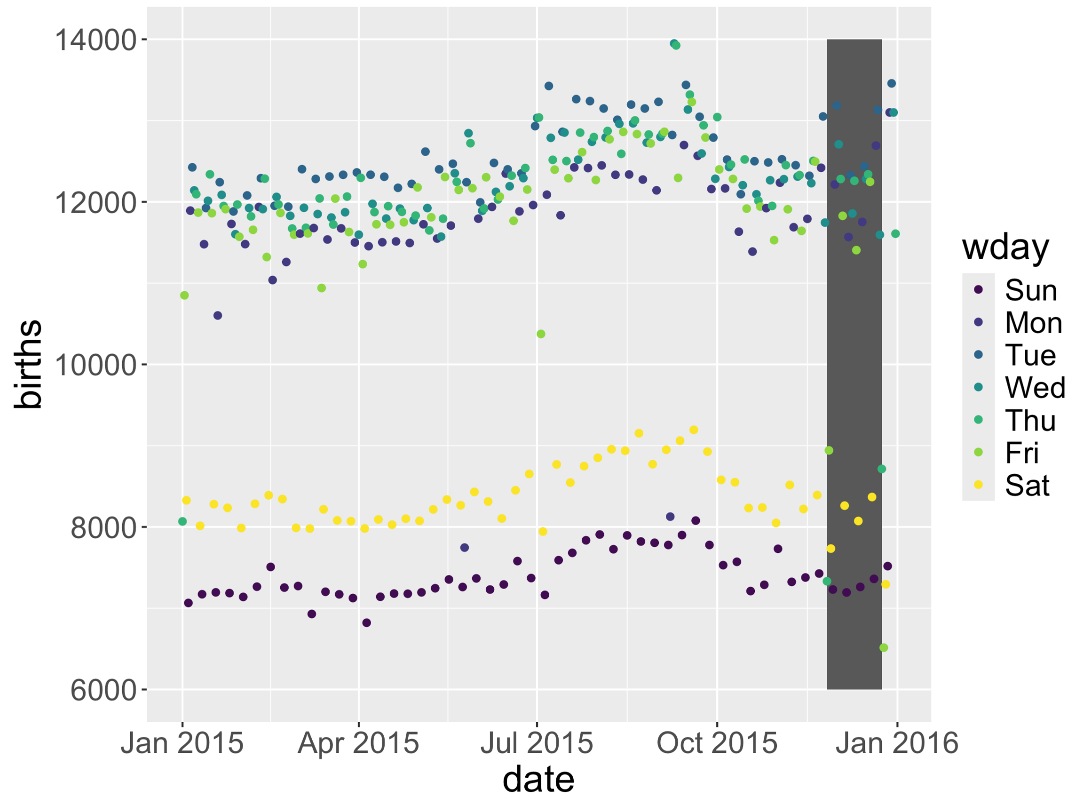
```r
ggplot(data = Births2015,
       mapping = aes(x = date, y = births,
                     color = wday)) +
  geom_rect(data = holidays_season,
            mapping = aes(xmin = start,
                          xmax = end,
                          ymin = 6000,
                          ymax = 14000),
             inherit.aes = FALSE) +
  geom_point()
```



- Problem: non-matching aes arguments
- One solution: set `inherit.aes = FALSE`

Safe Play: Put the mappings in the individual geoms

```r
ggplot(data = Births2015) +
  geom_rect(data = holidays_season,
            mapping = aes(xmin = start,
                          xmax = end,
                          ymin = 6000,
                          ymax = 14000),
             inherit.aes = FALSE) +
  geom_point(mapping = aes(x = date,
                           y = births,
                           color = wday))
```



- Problem: non-matching aes arguments
- Safer solution.

Now: plot animation and interactivity

Plot animation and interactivity

Plot animation

We'll use `gganimate` to make animated data viz

Plot interactivity

We'll use `plotly` to make interactive data viz

First up: animation

`gganimate` basics

- Core functions:
  - `transition_*()`: Defining the variables that control the change and how they control the change
  - `enter/exit*()`: Determining how data enters and exits
  - `view_*()`: Changing axes
  - `shadow_*()`: Giving the animation memory
  - `animate()`: Tuning the gif speed and size

Recall the babynames dataset

```r
library(babynames)
head(babynames)
```

```
# A tibble: 6 × 5
   year sex   name          n   prop
  <dbl> <chr> <chr>     <int>  <dbl>
1  1880 F     Mary       7065 0.0724
2  1880 F     Anna       2604 0.0267
3  1880 F     Emma       2003 0.0205
4  1880 F     Elizabeth  1939 0.0199
5  1880 F     Minnie     1746 0.0179
6  1880 F     Margaret   1578 0.0162
```

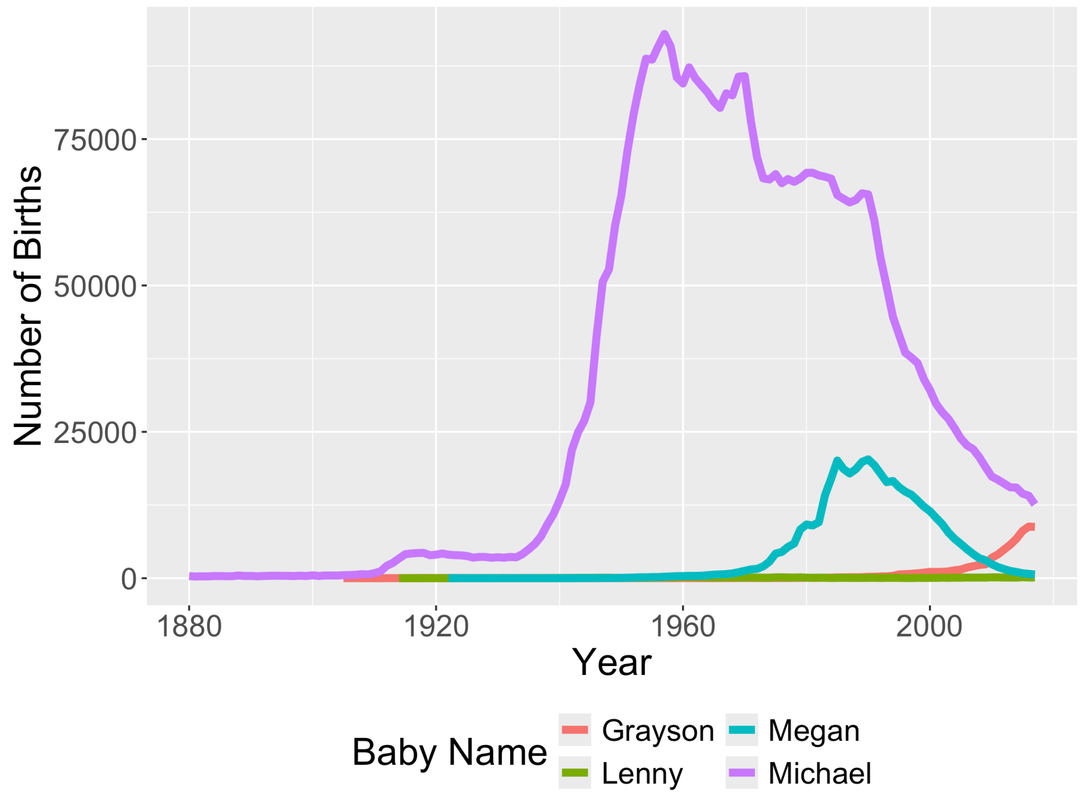
And our data wrangling

```r
babynames_math241 <- babynames %>%
  filter(name %in% c("Grayson", "Michael",
                     "Megan", "Lenny")) %>%
  group_by(year, name) %>%
  summarize(n = sum(n)) %>%
  ungroup() %>%
  arrange(desc(year))

babynames_math241
```

```
# A tibble: 431 × 3
    year name        n
   <dbl> <chr>   <int>
 1  2017 Grayson  8767
 2  2017 Lenny     118
 3  2017 Megan     624
 4  2017 Michael 12612
 5  2016 Grayson  8817
 6  2016 Lenny     134
 7  2016 Megan     744
 8  2016 Michael 14091
 9  2015 Grayson  8071
10  2015 Lenny     177
# ℹ 421 more rows
```

Now let's make a plot

```r
ggplot(data = babynames_math241,
       mapping = aes(x = year, y = n)) +
  geom_line(aes(color = name), size = 2) +
  theme(legend.position = "bottom",
        text = element_text(size = 20)) +
  guides(color = guide_legend(nrow = 2)) +
  labs(y = "Number of Births",
       x = "Year",
       color = "Baby Name")
```



Sidebar: saving plots to your computer

Here, I have an empty folder called “my_plots” in my working directory.

```r
list.files("my_plots")
```

```
[1] "stats_profs_an.gif"
```

Now, I save the plot **in my R environment** as the object p

```r
p <- ggplot(data = babynames_math241,
       mapping = aes(x = year, y = n)) +
  geom_line(aes(color = name), size = 2) +
  theme(legend.position = "bottom",
        text = element_text(size = 20)) +
  guides(color = guide_legend(nrow = 2)) +
  labs(y = "Number of Births",
       x = "Year",
       color = "Baby Name")
```

Finally, I use ggsave() to save the object to my computer

```r
ggsave(filename = "my_plots/stats_names.png",
       width = 10,
       height = 6)
```

Checking for files in “my_plots” directory

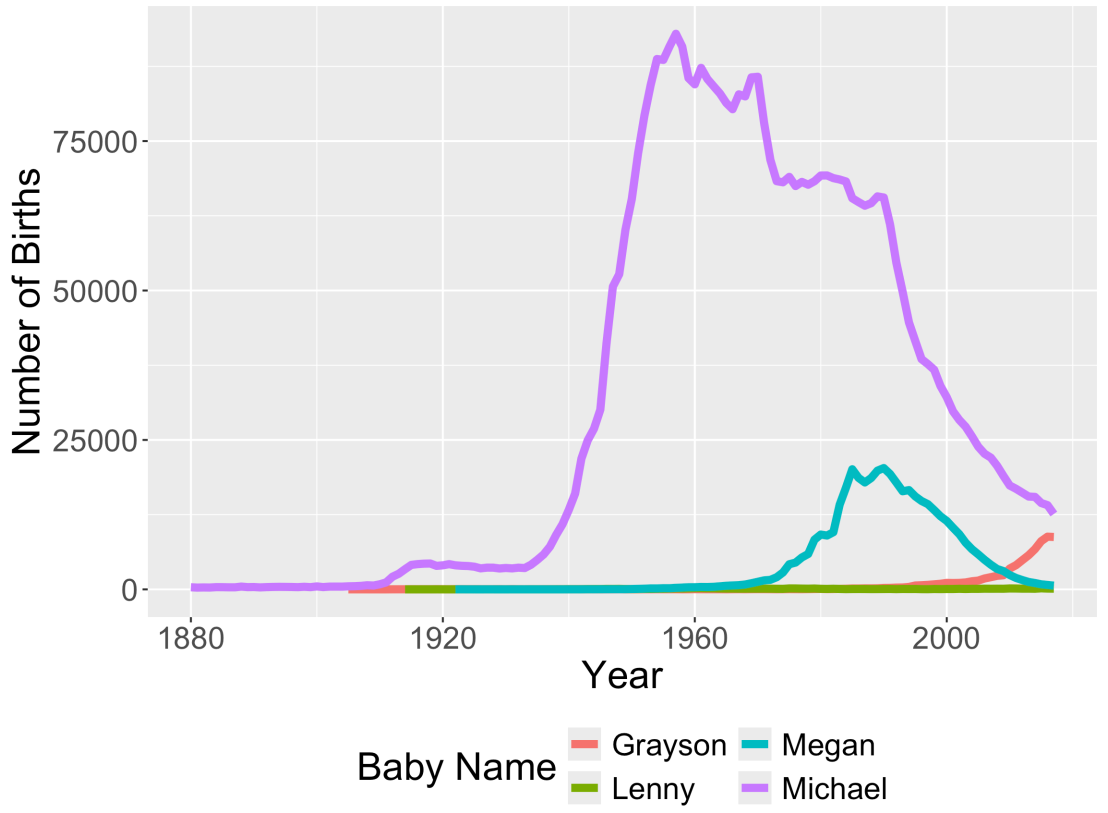
```r
list.files("my_plots")
```

```
[1] "stats_names.png"    "stats_profs_an.gif"
```

Back to animation

We'd like to animate this plot

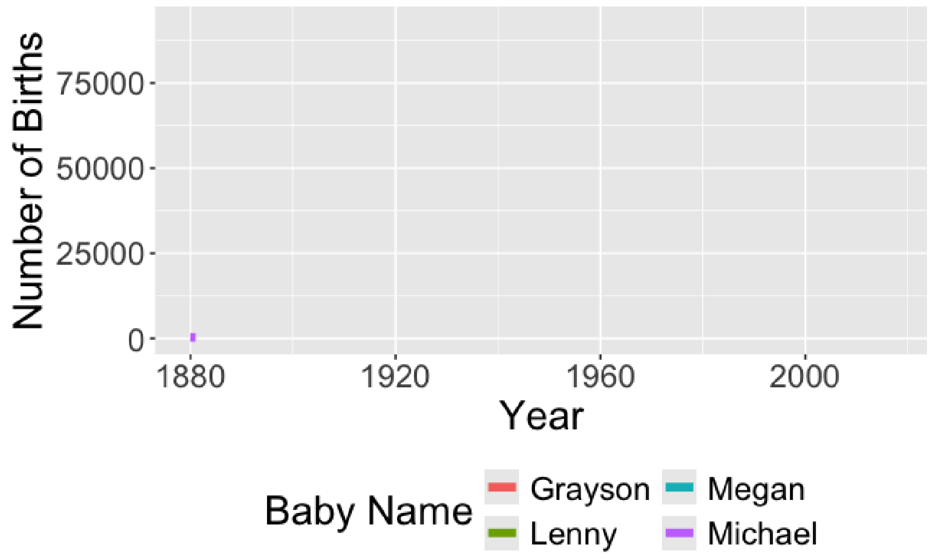
```
p
```



Back to animation

`transition_reveal()`: reveal the graph along a variable in the plot

```r
library(gganimate)
p_animate <- p +
  transition_reveal(along = year)
animate(p_animate,
        fps = 5,
        end_pause = 40,
        height = 4, width = 6.5,
        units = "in",
        res = 100)
```

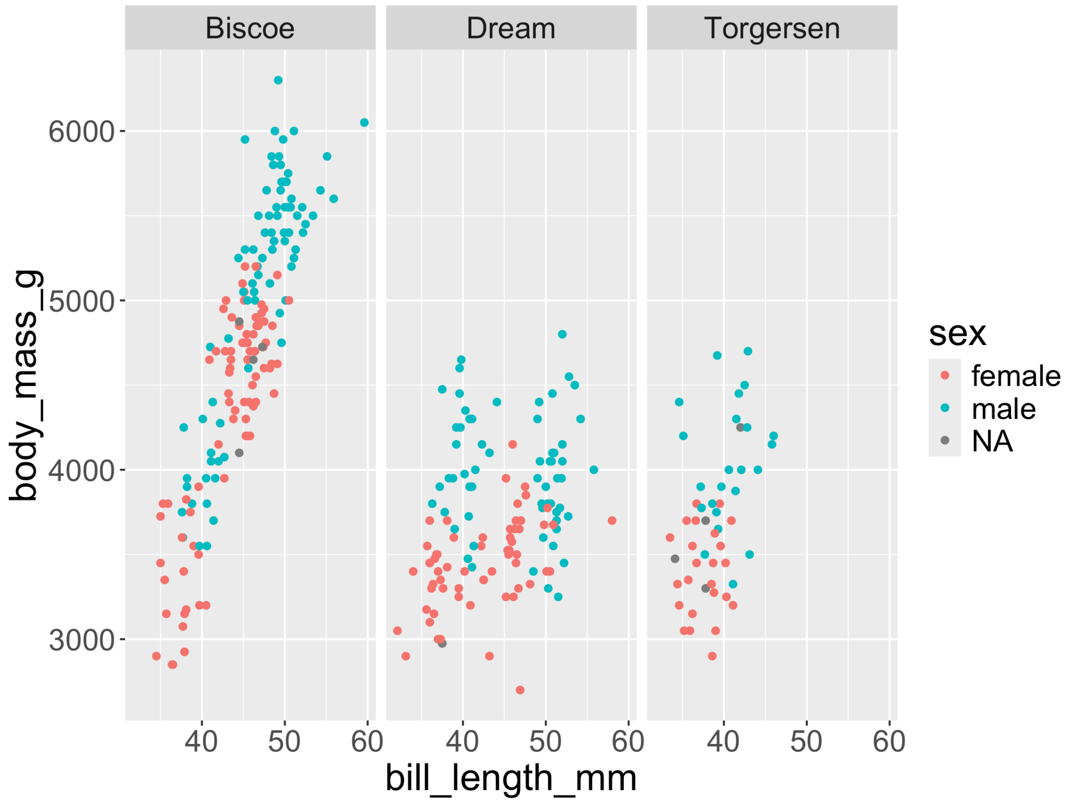


- Add the `transition_reveal()` function just like another ggplot layer.
  - Set the `along` parameter to the variable you'd like to reveal over.

Other `transition_***()` functions

Static graph by island

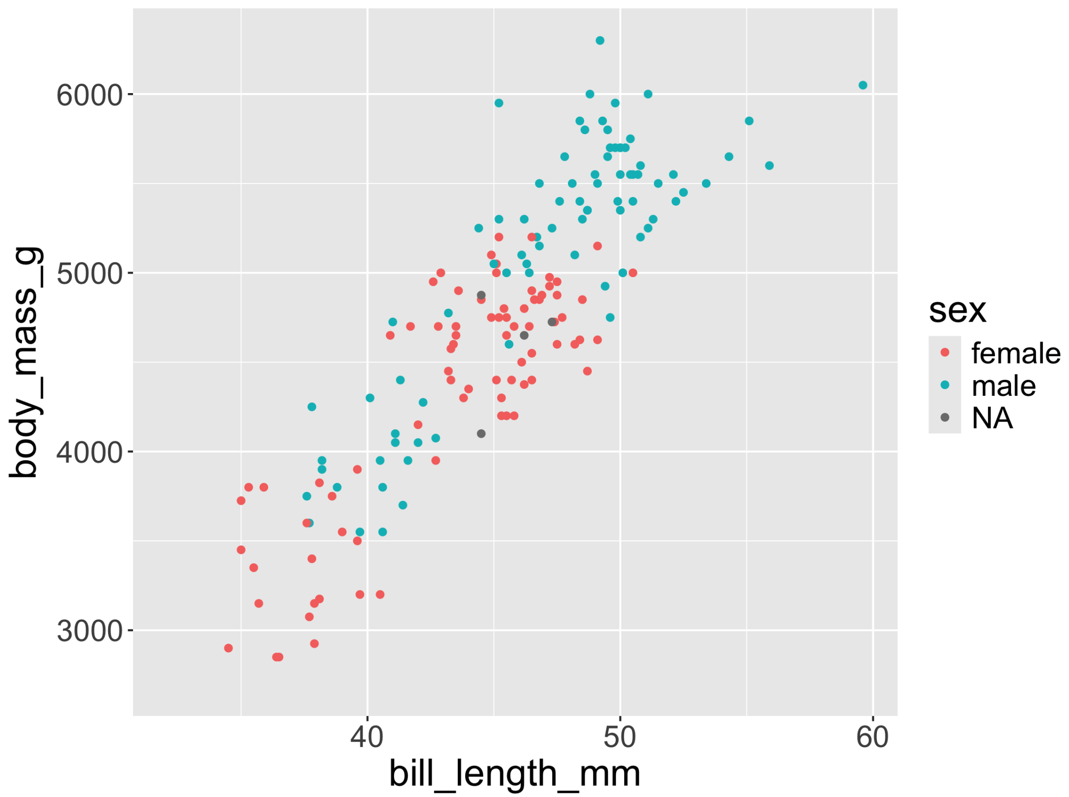
```r
library(palmerpenguins)
ggplot(penguins,
       aes(x = bill_length_mm,
           y = body_mass_g,
           color = sex)) +
  geom_point() +
  facet_wrap(~island)
```



Other transition_***() functions

transition_states(): display graph for each category of a variable

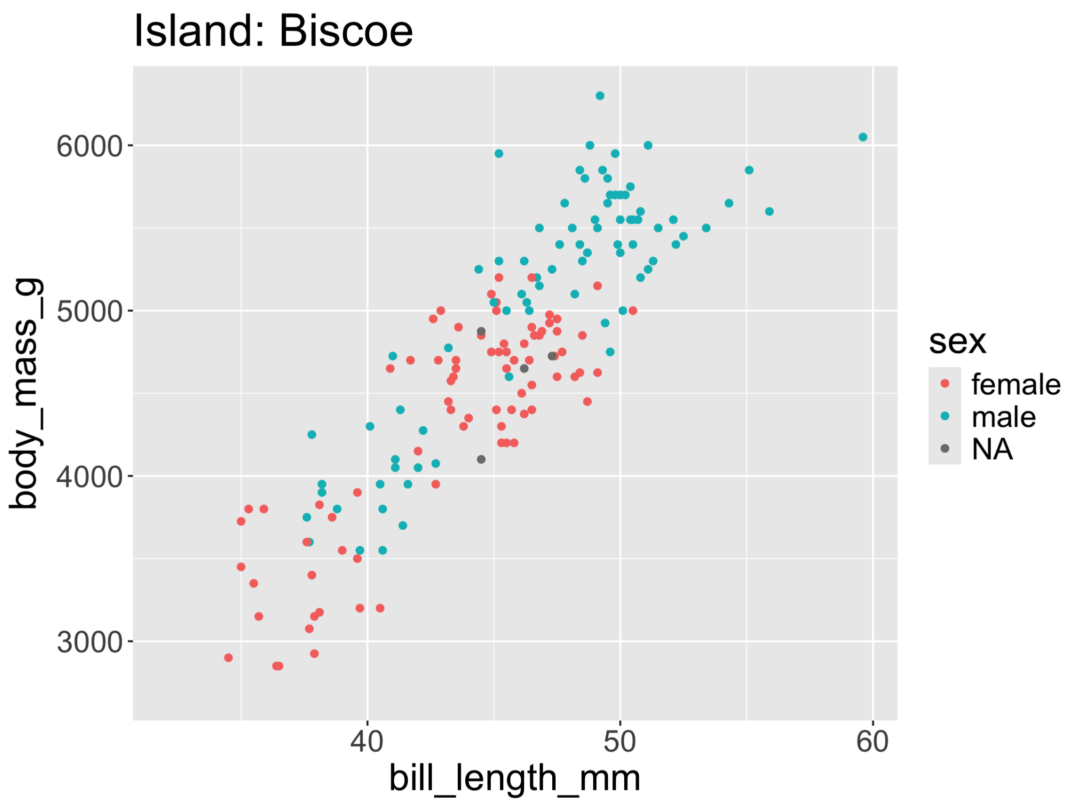
```
p2_anim <- ggplot(penguins,
                  aes(x = bill_length_mm,
                      y = body_mass_g,
                      color = sex)) +
  geom_point() +
  transition_states(
    states = island, wrap = TRUE
  ) +
  enter_fade() +
  exit_shrink()

animate(p2_anim)
```



Other `transition_***()` functions

`transition_states()`: display graph for each category of a variable

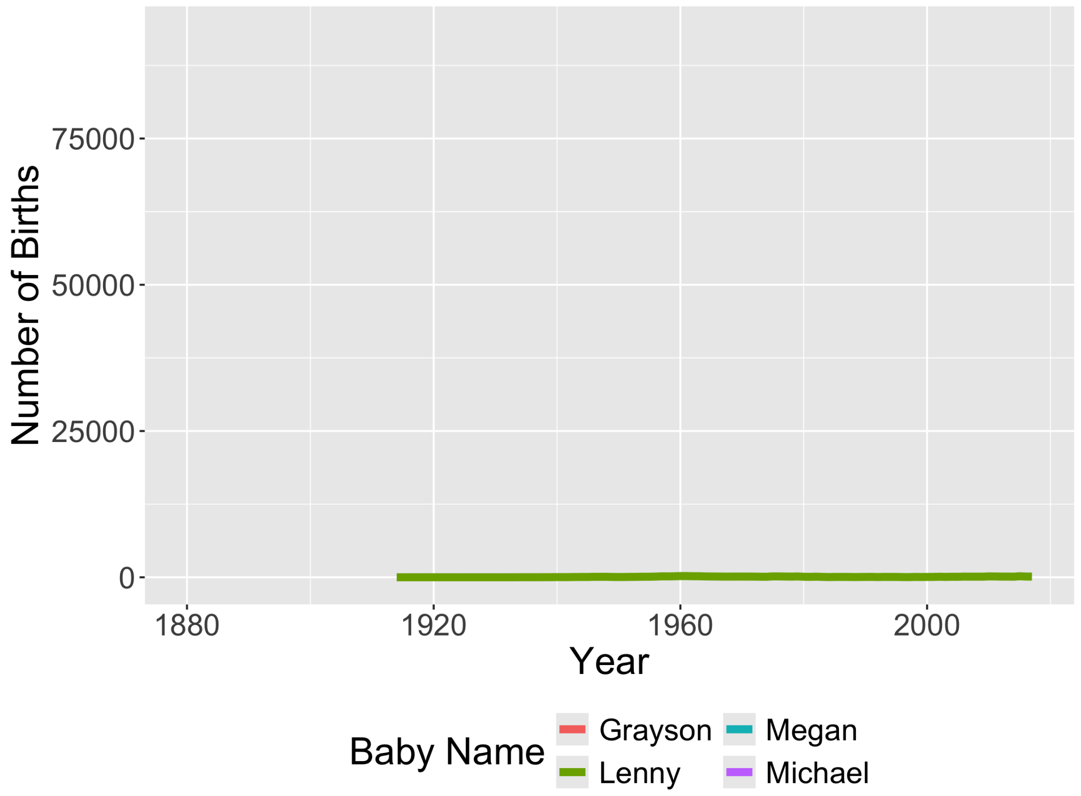
```r
p2_anim <- ggplot(penguins, aes(x = bill_length_mm, y =
  geom_point() +
  labs(title = "Island: {closest_state}") +
  transition_states(
    states = island, wrap = TRUE
  ) +
  enter_fade() +
  exit_shrink()

animate(p2_anim)
```



Other `transition_***()` functions

`transition_filter()`: display graph for multiple filtering conditions

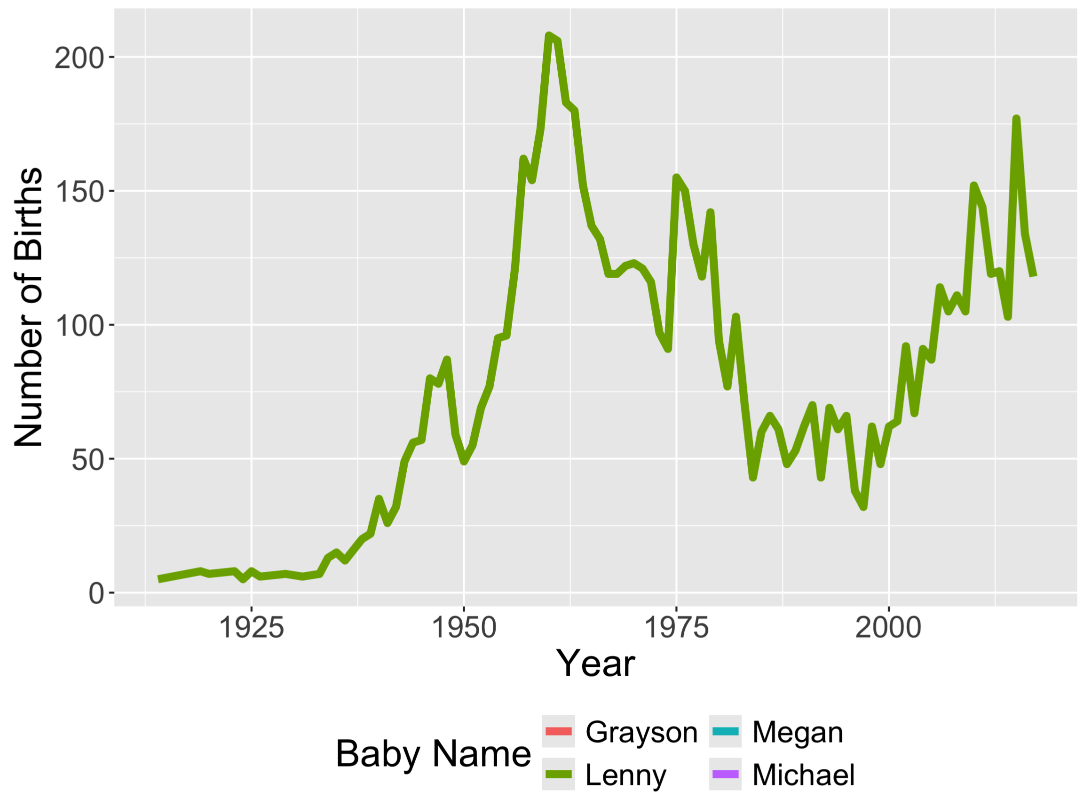
```r
stats_profs_anim <- p +
  transition_filter(
    Lenny = name == "Lenny",
    Grayson = name == "Grayson",
    Michael = name == "Michael",
    Megan = name == "Megan",
  ) +
  enter_fade() +
  exit_fade()

animate(stats_profs_anim)
```



Other transition_***() functions

view_follow(): let's us adjust the axis as we view

```
stats_profs_anim <- p +
  transition_filter(
    Lenny = name == "Lenny",
    Grayson = name == "Grayson",
    Michael = name == "Michael",
    Megan = name == "Megan",
  ) +
  enter_grow() +
  exit_fade() +
  view_follow()

animate(stats_profs_anim)
```



How do I save an animation?

```r
anim_save("my_plots/stats_profs_an.gif", animate(stats_profs_anim))
```

Why Add Animation to a Graph?

- To engage the viewer
- To accentuate the story
- To add another variable to the plot

But don't add animation just because you can. Drawbacks?

- Require a higher level of attention
- Can obscure the story

Animation: we're just scratching the surface!

- There are **tons** of different functions to fine-tune your animated pltos!

```r
apropos("transition_")
```

```
[1] "transition_components" "transition_events"     "transition_filter"
[4] "transition_layers"     "transition_manual"     "transition_null"
[7] "transition_reveal"     "transition_states"     "transition_time"
```

```r
apropos("exit_")
```

```
[1] "exit_disappear" "exit_drift"     "exit_fade"      "exit_fly"
[5] "exit_manual"    "exit_recolor"   "exit_recolour"  "exit_reset"
[9] "exit_shrink"
```

```r
apropos("^view_")
```

```
[1] "view_follow"      "view_static"      "view_step"        "view_step_manual"
[5] "view_zoom"        "view_zoom_manual"
```

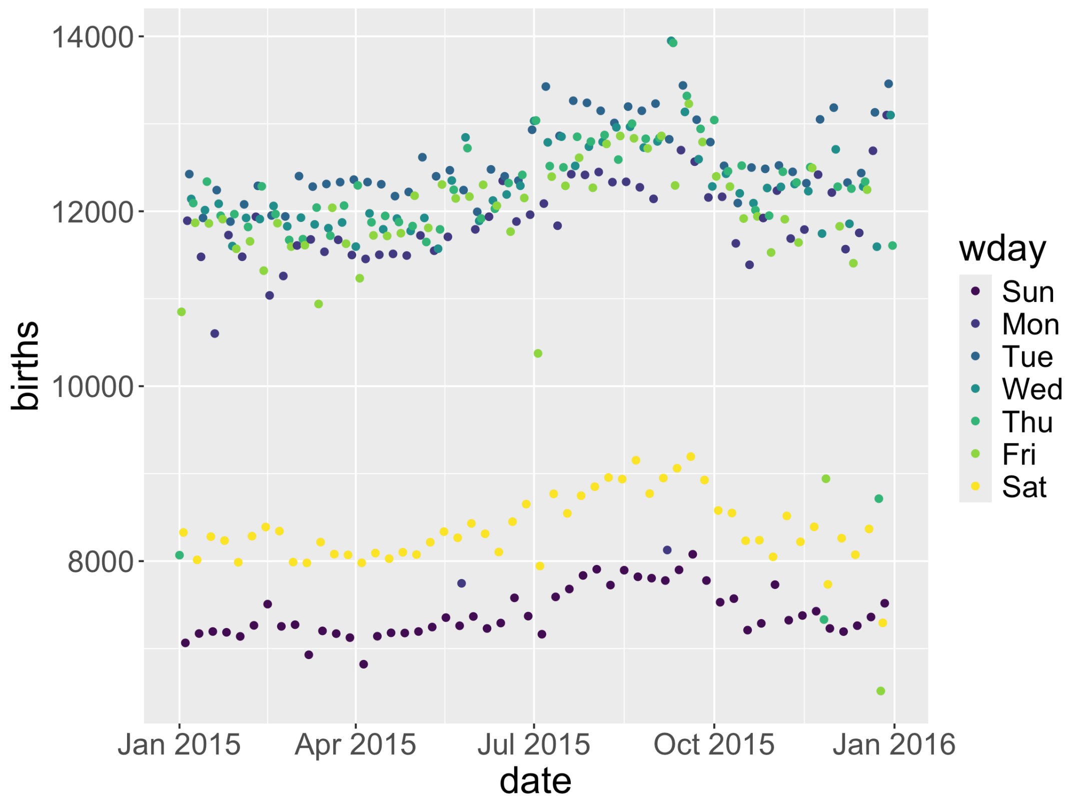
- Check the documentation for `gganimate` for even more excellent examples!
- And the `gganimate` cheatsheet is an excellent resource!

Now: interactivity

Simple Interactivity with `ggplotly`

We can use the `plotly` package to convert a static `ggplot` to an interactive plot.

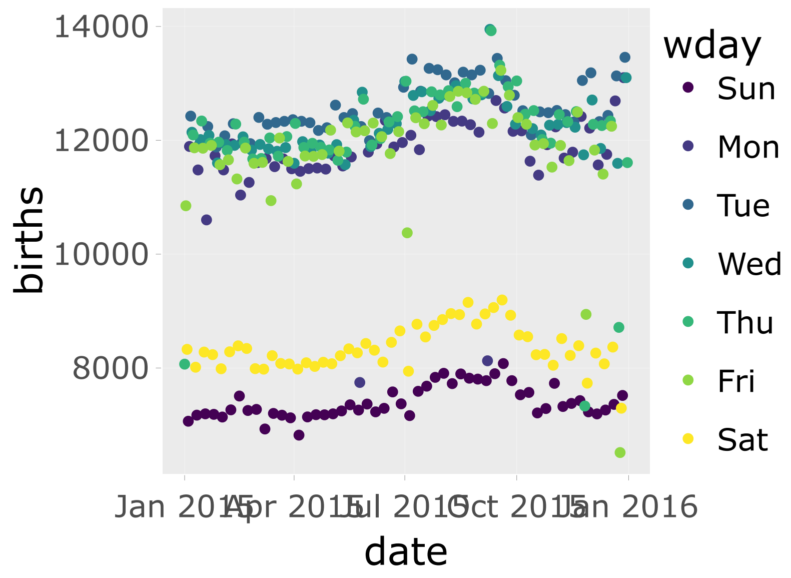
```r
library(mosaicData)
data(Births2015)

p <- ggplot(data = Births2015,
       mapping = aes(x = date, y = births,
                     color = wday)) +
  geom_point()
p
```



Simple Interactivity with `ggplotly`

We can use the `plotly` package to convert a static `ggplot` to an interactive plot.

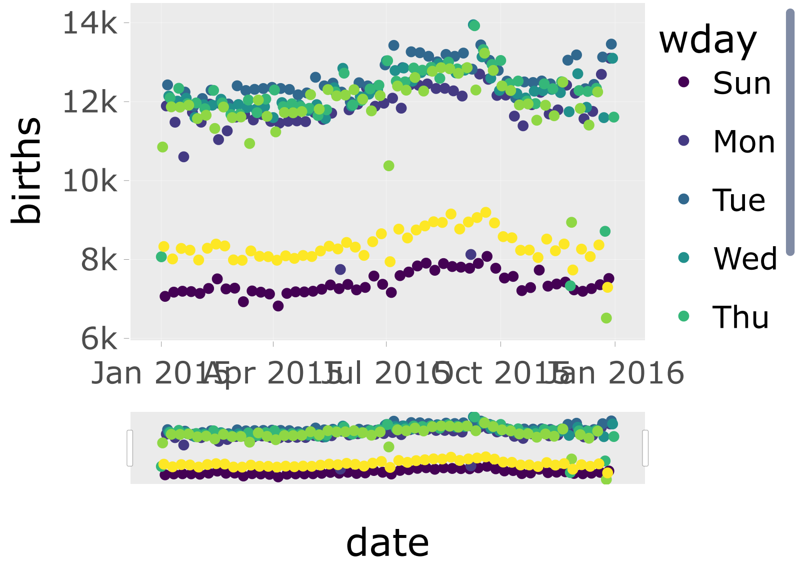
```r
library(plotly)
ggplotly(p)
```



- Conversion isn't always perfect.
  - May need to spend more time tweaking `theme()` beforehand.
- Can also create graphs with `plot_ly()`

Simple Interactivity with `ggplotly`

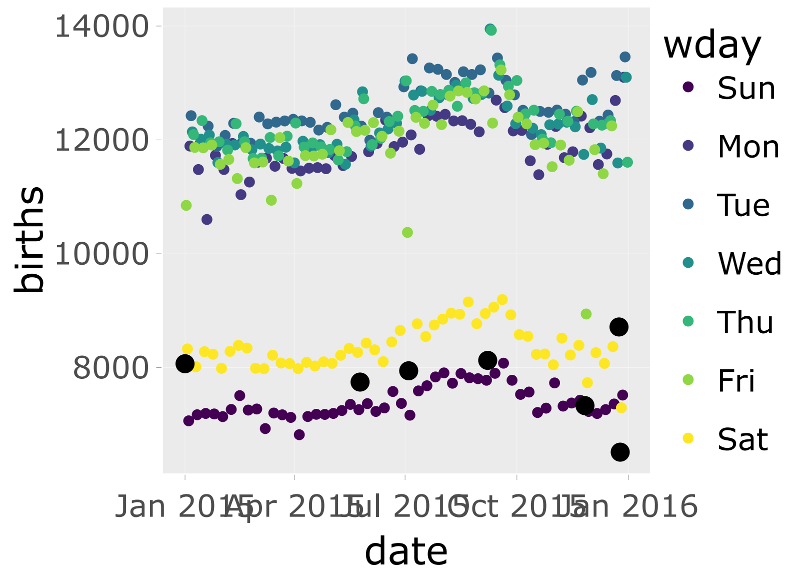
```r
ggplotly(p, dynamicTicks = TRUE) %>%
  rangeslider() %>%
  layout(hovermode = "x")
```



- Add a slider and make tick marks dynamic with zooming
- Change the comparisons made when you hover

Simple Interactivity with `ggplotly`

```r
p <- ggplot(data = holidays,
       mapping = aes(text = occasion)) +
  geom_point(data = Births2015,
             mapping = aes(x = date,
                           y = births,
                           color = wday),
             inherit.aes = FALSE) +
  geom_point(data = holidays, size = 3,
             color = "black",
             mapping = aes(x = Dates,
                           y = births))
ggplotly(p, tooltip = "text")
```



How do I save / share my interactive plots?

- Good question.
- In HTML format (website, dashboard, .html file).
- In Project 1, you'll create a `shiny` dashboard / app, which is one of the best way to share interactive plots and maps!
- We'll explore interactivity more in Problem Set 2.

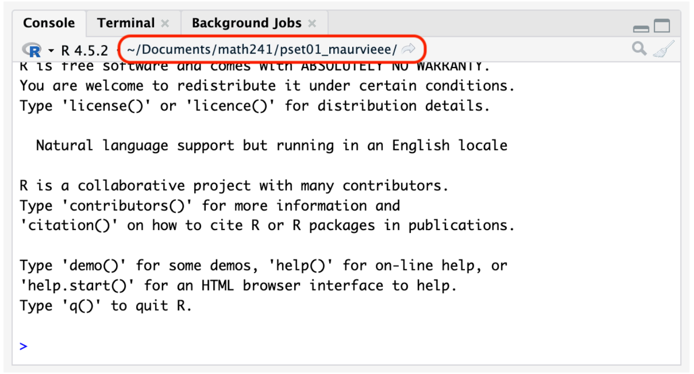
Workflow

Workflow review

- I’d like to spend a little bit more time discussing workflow with git, RStudio, and Positron
- And give you some slides to reference

RStudio Projects / Positron Folders

- Where does your analysis live?
  - Working directory
    - Where R looks for files you ask it to load.
    - Where R puts files you ask it to save.



```
R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

  Natural language support but running in an English locale

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

>
```

```r
getwd()
```

```
[1] "/Users/grwhite/courses/math-241/Reed-Data-Science.github.io/slides"
```

- For a given project, your analyses should live in the folder where you store the files associated with the project.
  - In other words, **working directory = project folder**.
- Common default: Working directory = home directory
- Can change the working directory with `setwd()` but instead we will use RStudio Projects or Positron Folders.

RStudio Projects and Positron Folders

RStudio Projects and **Positron Folders**: Feature that helps you organize your work.

- Each problem set will get it's own RStudio Project or Positron Folder
- The working directory is the home directory of the project.

- **Question**: My RStudio Project is `Reed-Data-Science.github.io`. Why does the file path end a folder furhter there when I run the following?

```r
getwd()
```

```
[1] "/Users/grwhite/courses/math-241/Reed-Data-Science.github.io/slides"
```

- R code executed in Quarto documents gets the working directory where that document lives, not the project directory
  - Confusing! But sometimes nice…

Projects and Workflow

- Create an RStudio Project / Positron Folder for each analysis project.
  - We will have nine RStudio Projects / Positron Folders for this course:
    - An RStudio Project / Positron Folders for each of Labs 1 - 6
    - An RStudio Project / Positron Folders for project 1
    - An RStudio Project / Positron Folders for project 2
- Each of these RStudio Projects / Positron Folders will be synced with `git` and GitHub

git and GitHub

- git: Version control system
  - Think fancier type of *Track Changes*.
- GitHub: Hosting service for git projects (which are called repositories)
  - Think fancier type of *DropBox* or *Google Drive*.
- Useful resource when getting started: https://happygitwithr.com/

Git Real

- Git is a *decentralized* version control system.
  - Each collaborator has a complete version of the repo.
  - Everyone can work offline and simultaneously.
  - GitHub holds the master copy.
- git is not friendly and can be frustrating. + BUT, the version control and collaborative rewards are big!
- GitHub.com is a great place to develop an online presence.
- If you end up with a mess of errors, then don't worry but come see one of the instructors for help.
  - It happens to everyone.

Main Message:

Github Repo = `RStudio` Project or `Positron` Folder

- A **repo**, short for repository, is the folder that contains all of the files for the project on GitHub.com.
- Under the **Reed-Data-Science** GitHub Organization you currently have 1 repo:
  - `pset01-username`: Just you and the Math 241 teaching team (me, course assistant, graders) can access
  - Soon, you'll have `pset02-username`
- For each repo, you should create an `RStudio` Project or Positron folder (with version control).

Next Week

- Big data wrangling week:
  - **Monday**: reshaping and joining data.
  - **Wednesday**: learn about different data types in R (beyond `data.frames`)

On the Horizon

- **Week 5**: spatial data
- **Week 6**: Interactive dashboards with `shiny` (and Project 1 assigned!)